PART of #7

PTO/SB/01 (10-01)
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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☒ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	
First Named Inventor	Hammer
COMPLETE IF KNOWN	
Application Number	10/055,785
Filing Date	01/09/2002
Art Unit	2859
Examiner Name	Stanley Pruchnic, Jr.

As the below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original and first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Conducted Heat Vector Sensor

(Title of the Invention)

the specification of which

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY) 01/09/2002 as United States Application Number or PCT International

Application Number 10/055,785 and was amended on (MM/DD/YYYY) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

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DECLARATION — Utility or Design Patent Application

Direct all correspondence to: [X] Customer Number or Bar Code Label [ ] OR [X] Correspondence address below

Name: Lawrence W. Langley

Address: 2733 Big Falls Road

City: Blacksburg | State: VA | ZIP: 24060

Country: USA | Telephone: (540) 961-2001 | Fax: 953-3010

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

NAME OF SOLE OR FIRST INVENTOR : [ ] A petition has been filed for this unsigned inventor

Given Name (first and middle [if any]): Robert | Family Name or Surname: Hammer

Inventor's Signature: Robert Hammer | Date: 4/29/03

Residence: City: Floyd | State: VA | Country: USA | Citizenship: USA

Mailing Address: 664 Beaver Creek Road, NW

City: Floyd | State: VA | ZIP: 24091 | Country: USA

NAME OF SECOND INVENTOR: [ ] A petition has been filed for this unsigned inventor

Given Name (first and middle [if any]): Lawrence W. | Family Name or Surname: Langley

Inventor's Signature: Lawrence W. Langley | Date: 4/29/03

Residence: City: Blacksburg | State: VA | Country: USA | Citizenship: USA

Mailing Address: 2733 Big Falls Road

City: Blacksburg | State: VA | ZIP: 24060 | Country: USA

[ ] Additional inventors are being named on the ____supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

A DOCPHOENIX

BACKFILE DOCUMENT INDEX SHEET

APPL PARTS

_____ IMIS ____
Internal Misc. Paper

_____ LET ____
Misc. Incoming Letter

_____ 371P ____
PCT Papers in a 371Application

50-03 A... 2
_____ A... ____
Amendment Including Elections

_____ ABST ____
Abstract

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Affidavit or Exhibit Received

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Appendix

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Artifact

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_____ CLM ____
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All CRF Papers for Backfile

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_____ DRW ____
Drawings

_____ FOR ____
Foreign Reference

_____ FRPR ____
Foreign Priority Papers

_____ IDS ____
IDS Including 1449

_____ NPL ____
Non-Patent Literature

_____ OATH ____
Oath or Declaration

_____ PET. ____
Petition

_____ RETMAIL ____
Mail Returned by USPS

_____ SEQLIST ____
Sequence Listing

_____ SPEC ____
Specification

_____ SPEC NO ____
Specification Not in English

_____ TRNA ____
Transmittal New Application

OUTGOING

_____ CTMS ____
Misc. Office Action

_____ 1449 ____
Signed 1449

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Abandonment

_____ APDEC ____
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Examiner Answer

_____ CTAV ____
Count Advisory Action

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Count Ex parte Quayle

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Applicant Remarks in Amendment

_____ XT/ ____
Extension of Time filed separate

Internal

_____ SRNT ____
Examiner Search Notes

_____ CLMPTO ____
PTO Prepared Complete Claim Set

_____ ECBOX ____
Evidence Copy Box Identification

_____ WCLM ____
Claim Worksheet

_____ WFEE ____
Fee Worksheet

File Wrapper

_____ FWCLM ____
File Wrapper Claim

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File Wrapper Issue Information

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File Wrapper Search Info

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PTO/SB/21 (05-03)
Approved for use through 04/30/2003. OMB 0651-0031
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	10/055,785
Filing Date	01/09/2002
First Named Inventor	Hammer
Art Unit	2859
Examiner Name	Stanley J. Pruchnic, Jr.
Attorney Docket Number	

Total Number of Pages in This Submission: 1

ENCLOSURES *(Check all that apply)*

- [X] Fee Transmittal Form
  - [X] Fee Attached
- [ ] Amendment/Reply
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [X] Response to Missing Parts/ Incomplete Application
  - [ ] Response to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) _____
- [ ] After Allowance communication to Group
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to Group **(Appeal Notice, Brief, Reply Brief)**
- [ ] Proprietary Information
- [ ] Status Letter
- [ ] Other Enclosure(s) (please Identify below):

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	Lawrence W. Langley
Signature	Lawrence W. Langley
Date	05/01/2003

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below.

Typed or printed name	Lawrence W. Langley		
Signature	Lawrence W. Langley	Date	05/01/2003

This collection of information is required by 37 CFR 1.5. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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7/Dec./a
TStephe
5/19/03

Lawrence W. Langley
U.S. Patent Agent, Professional Engineer
2733 Big Falls Road
Blacksburg, VA 24060
H(540) 633-2733 W(540) 961-2001

Tel corrected ema 7/15/03

May 1, 2003

IN THE UNITED STATES
PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF

Robert Hammer et al

Group Art Unit: 2859

Serial No. 10/055,785

Examiner: Stanley J. Pruchnic, Jr.

Filed: 01/09/2002

For: Conducted Heat Vector Sensor

The Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Response to Office Action of 3/10/03

Enclosed is a new Declaration by Inventors with the $65.00 surcharge for late filing required by 37 CFR 1.16(e)

OK to enter 5 pages spec with 5 pages spec of 7/15/03 - SP

Please replace page 1 of the disclosure with the attached page 1 and re-number the succeeding pages of the disclosure as 2-14. Also, delete page numbers on the drawings and the claims

Make the following changes to the claims.

Claim 9, second line, delete second occurrence of the word "a".

Cancel Claim 4 and 5.

Add the following claims 12-20:

12. The sensor of Claim 2 in which said plug is slotted on the side.

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BACKFILE DOCUMENT INDEX SHEET

A DOCPHOENIX

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File Wrapper Issue Information

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13. The sensor of Claim 2 in which said plug is slotted on the end.

14. A sensor for measuring temperature differences between a first and a second point within a solid body comprising:
a first and a second thin film thermocouple,
means for imbedding said first thin film thermocouple in said solid body at said first point,
means for imbedding said second thin film thermocouple in said solid body at said second point, and
means for measuring the difference in output potentials of said thin film thermocouples.

15. The sensor of claim 14 in which said means for imbedding said thermocouples consists of a plug closely fitting into a hole in said solid body and said thermocouples are deposited on said plug.

16. The sensor of claim 14 in which said means for imbedding said thermocouples consists of a thin substrate, and said thermocouples are deposited on said substrate.

17. The sensor of claim 16 further comprising a thin cover for said substrate.

18. The sensor of claim 15 in which the thermal properties of said plug match those of said solid body.

19. The sensor of claim 16 in which the thermal properties of said substrate match those of said solid body.

20. The sensor of claim 17 in which the thermal properties of said substrate and said cover match those of said solid body.

Claims 6 (two occurrences), and Claims 7, 8 and 10, change "object" to "body".

Claim 9, last line, add "for measuring its potential"

Discussion

The replacement Oath or Declaration contains a mailing address for both inventors.

A replacement Page 1 without the abstract is enclosed, and the pages of the application have been re-numbered according to Examiner's suggestion.

The second occurrence of the word "a" in Claim 9, second line has been deleted.

Examiner states, "- - - Sallée discloses the materials of the detector head matching the thermal properties of the solid object." Applicants respectfully request that examiner locate this text for them in the referenced patent.

Examiner rejected applicants' Claims 4 and 5 as being indefinite under 35 U.S.C. 112. These claims have been replaced by new Claims 12 and 13 which depend on Claim 2 and properly refer to the antecedents in this claim.

Applicants have changed terms in Claims 6,7,8 and 10 from "solid object" to "solid body", which conforms better to usage in the disclosure.

Examiner has rejected Claims 9, 10 and 11 Under 35 U.S.C. 112, second paragraph, as being incomplete for omitting essential steps. Only one step is omitted, that of measuring the thermopile potential. Claim 9 has been modified to correct this omission. The omissions in Claims 10 and 11 are corrected by their dependency on Claim 9.

Examiner rejected applicants' Claims 1 and 3-10 under 35 U.S.C. 103(a) as being unpatentable over Sallée etal, (US patent 4,817,436) in view of Nanigian (US patent 3,372,587). Examiner also rejected applicants' Claims 2 and 11 under 35 U.S.C. 103(a) as being unpatentable over Sallée etal in view of Nanigian and further in view of Medtherm. Applicants respectfully traverse examiner's rejections. The teaching of the Sallée etal patent combined with the teaching of Nanigian will not yield a heat flux sensor with the unique and novel performance characteristics of applicants' invention.

Sallée discloses a flexible heat flux sensor comprising a thin composite structure of copper, constantan and mylar sheets, etched and bonded together. The patent does not describe how this combination senses heat flux, and does not indicate the direction of heat flow through the device. However, the design is well described in the reference "Measurements on the thermoelectric propertiesof thin layers of two metals in electrical contact. Application for designing new heat-flow sensors", Meas. Sci. Technol. 3 (1992), Ph. Herin and P. Théry, pp 495-500. A copy of this reference is attached.

The Sallée etal device measures heat flux passing through its thinnest dimension by creating small local temperature gradients normal to the heat flow, i.e. in the plane of the device. The gradients are produced by geometric asymmetries in the heat flow paths around rectangular voids

in the composite. Pairs of copper/Constantan thermocouples on opposite sides of the voids sense these gradients and produce slightly different voltages. When connected in series opposition the net voltage of each pair of thermocouples is proportional to the heat flow. The small net voltages for many pairs of thermocouples are summed by series connection to produce a larger signal indicative of heat flux. Because the basic measuring principle requires that temperature gradients be developed in the plane of the device, it is not well suited to measuring conductive (or convective) heat flux. If a surface of the device were to be placed in contact with a thermally conductive solid, or if the device were to be imbedded in a solid body, the temperature gradients in the plane of the sensor would be reduced or eliminated by conduction through the conductive solid, and the sensitivity of the device to heat flux would be reduced by an indeterminate amount. Sallée etal have added thin layers of mylar 2 and 24, and layers of copper 20 and 26 on the faces of the device to reduce this effect, but it cannot be eliminated.

Applicants' objectives for their invention could not be achieved by utilizing the Sallée etal device or its principles. If this device were directly substituted for the thin film thermopile of applicants' invention, the resulting sensor would be completely insensitive to heat flux along the sensor axis. To cause heat to flow through the device and provide sensitivity to the axial component of heat flux, it would have to be installed at right angles to the axis so that heat would flow through its thinnest dimension. This would present a large area with different thermal properties from those of the solid object whose heat flux is to be measured. Heat would be shunted around the sensor, and the pattern of heat flow in the solid object would be severely perturbed.

By contrast applicants' invention presents an extremely small area in the direct path of heat, an "end-on" view of the thin films. Because the thin films are tightly held between surfaces of a material whose thermal properties closely match those of the solid object, the perturbation of heat flow will be negligible, regardless of its actual direction. There is no way to imbed the Sallée etal device in a solid object to achieve a comparatively negligible distortion of heat flow.

Despite its title, the Nanigian patent does not describe a direct reading heat flow detector. What it does describe is a temperature sensor with provisions to minimize perturbations in heat flow caused by installation of the sensor in a solid object. To measure heat flow with this sensor, one must calculate the first derivative of measured temperature and apply scaling factors that are functions of the physical dimensions and material properties of the solid object. This is what is generally termed an "inverse" problem. The undesirable magnification of noise and error by the required mathematical differentiation process is well known. The means for calculating a heat flux from the signals of this device are not described in the patent.

Substitution of the Sallée etal device for the flat plate of the Nanigian patent would result in a heat flux sensor, but one that would significantly perturb the flow of heat. In column 2, line 67-72 of Nanigian the inventor warns against trapping air bubbles during installation and potting of the sensing element in the wall. "- - - any such would cause errors due to their interference with the normal flow of heat by virtue of their different heat transmission characteristics as compared with the wall." However, the Sallée etal device contains many voids that are required for it to function as a heat flux sensor. These are clearly identified as channels 16 in Figure 2a of the

patent. Thus the two patents teach in opposite directions and cannot reasonably be combined.

One might ask why applicant's invention has not been derived by others from Sallée and Nanigian, given that the former has been available to the public for almost 14 years, the latter for over 25. The answer is that they cannot be combined in any way to achieve the desired characteristics. Only by imbedding a thin film thermopile within the object as taught by applicants, can the following objectives be achieved:

simplicity of construction;
negligible disturbance of heat flow in the object;
measurement accuracy;
durability in service;
wide operating temperature range; and
low cost.

In their invention applicants have used the characteristics of a thin film thermopile to particular advantage. While the metals making up the thermopile may have very different thermal properties from those of the surrounding material, the cross-sections and masses of the metal films are so small that only a negligible perturbation of heat flow results. If the dimensions of the thermopile and the properties of surrounding material are accurately known, heat flux can even be deduced from the sensor signal without a prior calibration.

In a recent joint proposal by Vatell Corporation and Oak Ridge National Laboratory to the Department of Energy entitled Heat Flux Sensors for Materials Processing, the characteristics of applicants' sensor and its advantages were described. Following is a direct quotation from that proposal.

1.1 Nonproprietary Project Summary

In this work, heat flux sensors will be designed and fabricated for data acquisition and process monitoring in metallurgical processes. The sensors will provide information on the heat transfer at solidifying interfaces for those industrial processes in which the processing material evolves from a state of liquid, semisolid, to solid state. By measuring directly the heat fluxes at interfaces with processing materials, the design and monitoring of materials processes will be enhanced. The knowledge of the instants at which the interface gaps appear and grow would provide a new process monitoring tool. In addition, the direct heat flux data measured by the sensor will provide important and accurate data for the design of molds, risers, and gating systems in the aluminum, metalcasting, and steel industries. The robust design of the sensors for high performance and extended life in hostile environments with include selective coating of the sensor components using advanced photonics processing techniques.

1.2 Project Relevance to the research priorities identified in the technology roadmaps

The proposed heat flux sensors will revolutionize solidification processing through (a) the measurement of heat flux at solidifying interfaces, a quantity that is inherently sensitive to

small interfacial changes, creating new opportunities for process monitoring and control, and (b) providing a new tool for determining more accurate heat transfer coefficients without involving cumbersome inverse heat transfer analyses.

The project will addresses sensors needs of at least three Industries of the Future:

Aluminum industry: The proposed sensors will be applicable to aluminum industry as a new monitoring tool, which is highly desired by the industry: "Limitations in sensors and other measurement capabilities currently restrict aluminum fabricators' knowledge of process specifics, in turn limiting the precision with which they can control processes to optimize productivity, quality, and efficiency." (p. 29). The sensors will also provide very useful information on temperature gradients at mold surfaces (see Exhibit 4-2, p. 30. on Sensors and Measurement -"Inability to measure thermal gradients in the process for temperature control.")

Steel industry; Generic casting: The sensor will enable (a) "Develop the ability to monitor the process to ensure consistent quality." (p. 31, p. 48), (b) "Develop advanced heat transfer and fluid flow models." (p. 48) through more accurate estimates of heat transfer boundary conditions at solidifying interfaces, and (c) "Enhance education on the science and engineering principles involved in the design and operation of casters." (p. 48).

Metalcasting industry: Since it addresses major technological barriers, there is a strong potential for the proposed sensor to revolutionize the metal casting industry. Example of road map areas impacted by the proposed sensors include: (a) Major Technological barriers: Sensors and controls: "current sensors cannot detect subtle changes" (Exhibit 4-2, p. 32); the heat flux sensor is inherently very sensitive to the interfacial changes, such as the appearance of mold-casting interface, (b) R&D Needs in Manufacturing by Time Frame: Sensors and controls: "Develop robust sensors and controls suitable for hostile environments." (High priority, Exhibit 4-3, p. 36), (c) "Available sensors and controls are not robust or sophisticated enough to measure and control all the process parameters." (p. 34), and (d) "The lack of advanced sensors and process controls that can withstand the hostile environments inside and around the melting and holding furnaces is a key barrier to achieving energy efficiency goals." (p. 35).

1.3 Organizational Plan and Specialized Capabilities

The key organizations are Secat, Inc., Vatell, Corp., University of Tennessee, MCT, Inc., FlowScience, Inc., and Oak Ridge National Laboratory. Secat, Inc. will be responsible for general coordination of the project.

The collaboration of UT and ORNL will bring a wealth of experience as well as unique facilities and capabilities to bear on the project.

The University of Tennessee will lead the development of coating systems (materials) and coatings-related analysis and assist in the design of sensor.

RNL will leverage its results from the significant effort already underway in the areas of coating and substrate deposition using IR lamp, numerical simulation of solidification processes, the experience and facilities in casting areas, data acquisition and ensuing post-processing. processing. Infrared Processing Center of ORNL is the only center of its kind involved in developing material processing related to wear and corrosion.

Secat, Inc. is a business conceived and dedicated to facilitating research and development of innovative technology and products for the aluminum industry. The project team will have access to aluminum companies that are part of the consortium lead by Secat, Inc.

Vatell, Corp. provides four different types of heat flux measurement instruments, covering a wide area of industrial applications.

Flow Science, Inc. is one of the leading software vendors in computational fluid dynamics and heat transfer that is widely used in casting community.

MCT. Inc. will provide wealth of information and guidance in metal casting requirements during design of the sensors and also provide an access to casting facilities for testing prototype sensors for their optimum performance. (End of quotation)

This quotation is evidence of a long unsatisfied need in the casting industry for a sensor with the characteristics of applicants' invention. The company Medtherm Incorporated, whose product brochure is referenced in examiner's rejection, has been in the heat flux sensor business for over 25 years. That company's engineers are certainly familiar with the state of the art of sensor design. Even so, they have never disclosed or sold sensors with the features and advantages of applicants' invention.

The references cited by examiner are ample evidence that no one having ordinary skill in the art has ever realized the advantages of imbedding a thin film heat flux sensor in a solid object in the manner taught by applicants. After careful review of these references, applicants have concluded that the claims submitted with the original application are not as broad as they might be. New claims 14 through 20 are submitted herewith. The support for this addition is as follows.

The heat flow measurement described by Nanigian is a Type 2 Method - Temperature Change With Time, as termed by Diller. See p. 307, Advances in Heat Transfer, Vol. 23, Academic Press, Inc. Only a single point temperature measurement is required, but the history of the temperature must be recorded over a time and heat flow is then calculated by an inverse method. The Nanigian, Paine and Mele references describe various ways to improve the accuracy of such measurements, but do not contemplate direct sensing of heat flux. By contrast, applicants' invention is a Type 1 Method - Spatial Temperature Difference, also in Diller's terms. It is more commonly known as a direct reading method for measuring heat flux - the signals of the sensor are directly proportional to heat flux.

The Geraschenko, Hevey, Hines, Leins, Malang, Medtherm and Sallée references all refer to direct reading heat flux sensors, but none contemplates the imbedding of a thin film thermopile in a solid body in such a manner as to minimize the distortion of heat flow caused by the sensor. The Sallée and Medtherm sensors measure heat flux along one axis by developing a thermal gradient normal to that axis. This technique cannot be used for conductive heat transfer because the thermal gradient is "shorted out" by contact with the thermally conductive body. The remaining references utilize one or another form of thermal resistance placed in the path of heat flow to produce a thermal gradient aligned with the heat flow. None of these methods can be